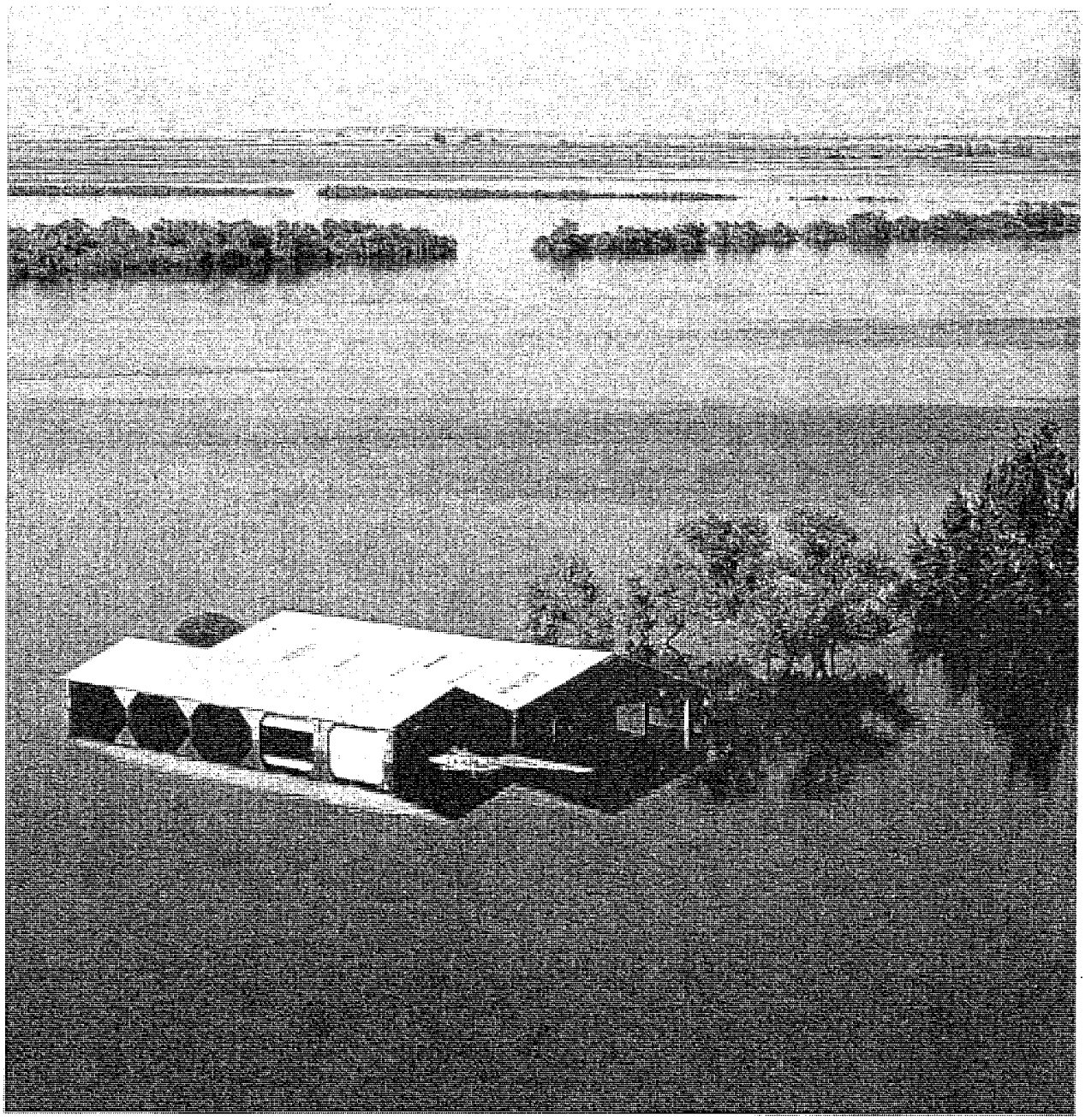
LAYPERSON'S GUIDE TO

Flood Management

Prepared by the Water Education Foundation



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The mission of the Water Education Foundation, an impartial, nonprofit organization, is to create a better understanding of water issues and help resolve water resource problems through educational programs. For more information contact:

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On the Cover:

In June 2004, a levee protecting a Delta island, Jones Tract, unexpectedly failed – flooding the island.

Cover photo by the California Department of Water Resources

Introduction

When people think of natural disasters in California, they typically think about earthquakes. Yet the natural disaster residents are most likely to face involves flooding, not fault lines. In fact, all 58 counties in the state have declared a state of emergency at least three times since 1950.

Dealing with these often devastating floods can be daunting, especially as an event occurs somewhere in the West nearly every year.

As Mark Twain wrote in the 19th century, 10,000 River Commissions "cannot tame that lawless stream, cannot curb it or confine it; cannot say to it, 'go here or go there,' and make it obey; cannot save a shore which it has sentenced; cannot bar its path with an obstruction which it will not tear down, dance over and laugh at."

During heavy rains in California, large rivers as well as smaller streams and creeks can become dangerous, as the last half century shows. In 1955, floods in Northern and Central California killed 67 people. In 1964, a savage storm struck the north coast of California when the Eel River roared out of the mountains carrying more than 800,000 cubic feet per second (cfs) – the average flow is 7,200 cfs. Twenty-four people were killed.

In 1997, flood waters overpowered levees on the San Joaquin, Cosumnes, Feather, Bear and Yuba rivers, and the Sutter Bypass, causing nearly $2 billion in damage.

In 1986, floods devastated much of Central California, killing 14 people and causing $1.5 billion in property damages. The next year, 48 of the state's 58 counties were declared disaster areas after the New Year's subtropical storms hit, killing nine people, forcing 120,000 people to evacuate their homes and causing nearly $2 billion in damages impacting 23,000 homes. Record rainfall in 2004 caused extensive localized flooding in parts of Southern California.

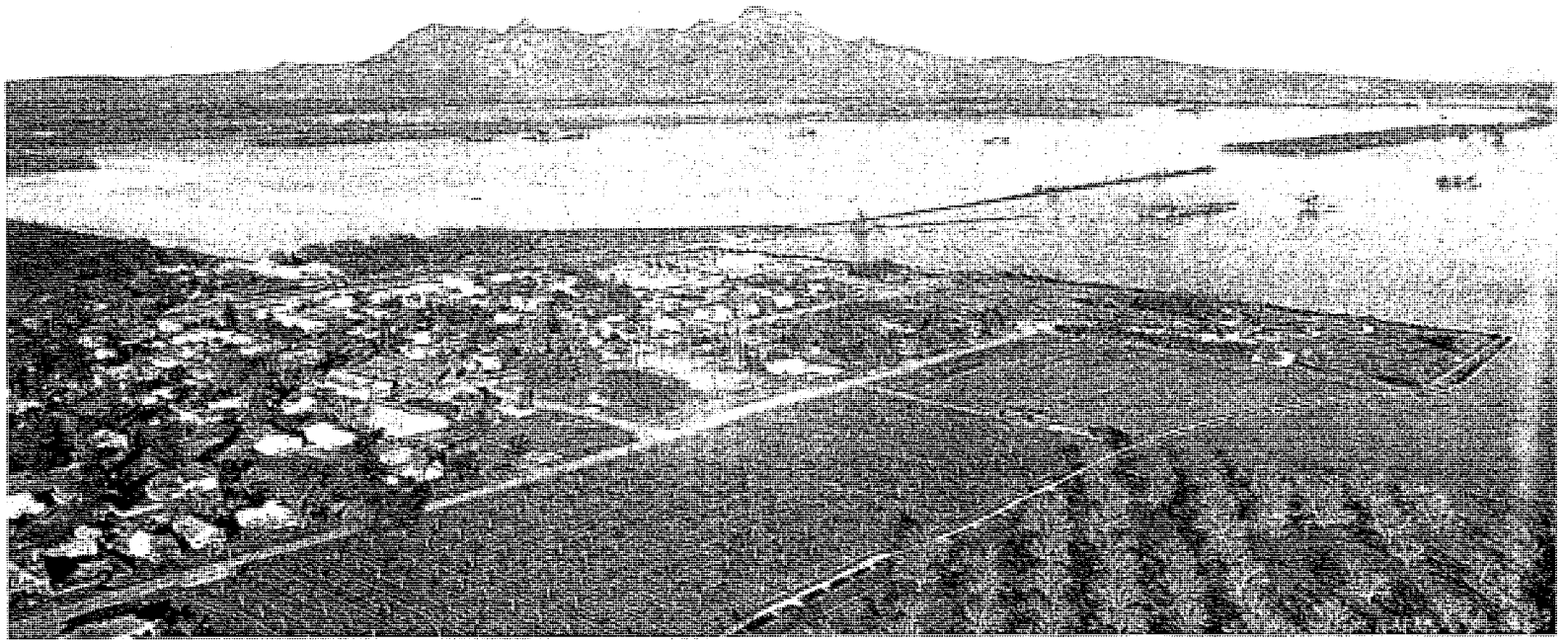
Upstream dams have done much to reduce this flooding, but whether downstream levees can provide adequate protection in some areas is a big concern. In 2005, the destruction of New Orleans by Hurricane Katrina brought new attention to levees throughout the United States, including California, and the potentially fatal impacts of their failure in urban areas within floodplains. According to the California Department of Water Resources (DWR), protection provided by most California levees is much lower than what New Orleans thought they had.

The city of Sacramento, for example, only has about a 100-year level of flood protection – a 1 percent chance of a flood disaster occurring each year. In other words, a homeowner in such an area has a one-in-four chance that a flood of that magnitude will occur sometime during a typical 30-year mortgage. This is much less protection than most major cities in the United States. And by comparison, the river cities of Tacoma, St. Louis and Kansas City have 500-year levels of protection. New Orleans was thought to have a 250-year level prior to Hurricane Katrina.

Flooding in California is not only caused by hard rains. On a bright, sunny day on June 3, 2004 a levee in the Sacramento-San Joaquin River Delta crumbled and sent surging river water into Upper and Lower Jones Tract west of Stockton. Total costs related to the levee break were estimated at about $90 million, including millions of dollars in direct flood fighting and levee-repair costs, and millions more in losses of crops and property.

In the Delta, there are approximately 1,100 miles of levees protecting 700,000 acres of lowland. In the Suisun Marsh, there are approximately 230 miles of levees protecting over 50,000 acres of marsh land.

To determine the magnitude of the Delta flood risks, the Delta Risk Management Strategy (DRMS) assessed major risks to Delta levee resources from floods, seepage,



subsidence, and earthquakes. In 2008, DRMS' Phase I report found a better than 60 percent chance that an earthquake or major flooding in the Delta will cause multiple levees to fail simultaneously in the next half century.

While some critics question the extent of the risk, it is clear that California needs better flood protection. Yet flood management is inextricably intertwined with politics, economics and values. Historic floodplains have been heavily developed for agricultural, commercial and residential use. In California's Central Valley, a growing population has pushed subdivisions into floodplains previously leveed off for agricultural use, often without recognizing the inadequate level of protection provided by the existing flood management infrastructure. The relative risk of flooding is a remote concern for many people living in floodplains, though their houses are more likely to incur damage from a flood than a fire.

Floods affect every Californian because flood management projects and damages are paid with public funds. The state fluctuates between having too much or not enough water, so a delicate balance between flood protection and water supply operations must be struck. In addition, riparian habitat and fish and wildlife impacts must be factored into the flood management equation. Adding to the complexity is the range of federal, state and local entities involved in flood management.

The effects of climate change further complicate flood risk management in California. Reports tout uncertainty and dire consequences for the future, yet impacts of climate change are already being felt on water resources – the availability, quality, flood management, ecosystem functions and distribution throughout the state.

Precipitation and runoff patterns are changing, which could impact the timing and magnitude of flows. Expected impacts include more precipitation falling as rain rather than snow. An earlier melt to the winter snowpack is also expected. The California Climate Change Center says increasing coastal floods are expected, because increasingly severe winter storms, rising sea levels and high tides are expected to cause more frequent and more severe flooding, erosion and damage to structures along the coast.

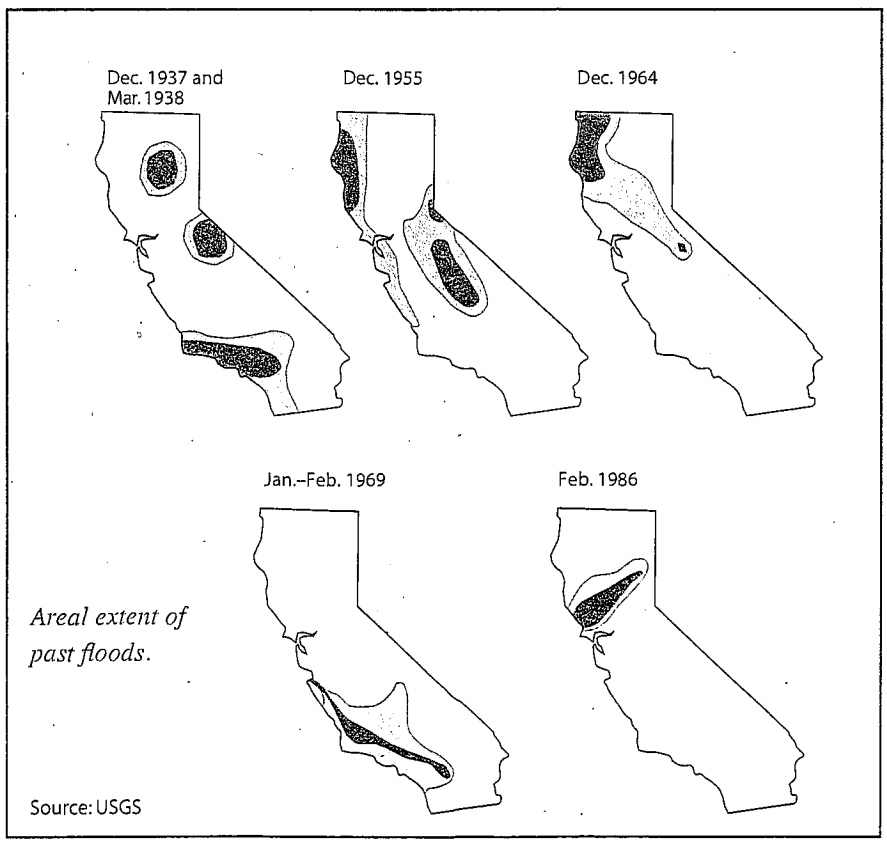
Even without considering climate change-related issues, California's flood protection system is facing unprecedented changes, including increasing floodplain development, rising flood peaks, higher costs that delay fixing problem levee sites, the need for environmental protection and greater state liability for levee breaches portending an ominous future. In a 2005 white paper, *Flood Warnings: Responding to California's Flood Crisis,* DWR warned that the Central Valley's flood protection system is "deteriorating and, in some places, literally washing away."

Through DWR's FloodSAFE California Initiative local, regional, state, tribal and federal officials have teamed up to create sustainable, integrated flood management and emergency response systems throughout California. Goals include providing a 200-year level of protection to all urban areas in the Sacramento-San Joaquin Valley by the end of 2025.

In 2006 California voters approved Proposition 1E and Proposition 84, which provided a $4 billion general obligation bond to pay for work including levee repairs in the Delta and Central Valley, improved flood protection for cities and stormwater flood projects. Governor Arnold Schwarzenegger in 2007 signed several bills to strengthen flood protection in California, mostly in the Central Valley. This legislative package will lead to the development of a comprehensive Central Valley Flood Protection Plan.

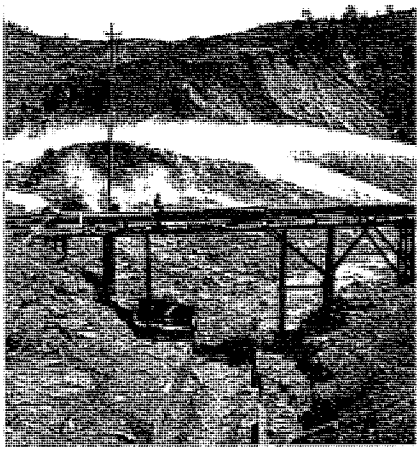
This Layperson's Guide explains the basics of flood management, how and why flood management projects are operated, how the various agencies involved coordinate and share costs and the challenges of maintaining these vital projects.

Historic patterns of seasonal inundation – pre-project.



Areal extent of past floods.

Background



During the Gold Rush, hydraulic mining was widely used to wash away hillsides and uncover veins of gold in the Sierra foothills. The resulting sediment floated downstream and clogged river channels, causing devastating floods. Flood waters more than 20 feet deep were measured in downtown Sacramento during the flood of 1862.

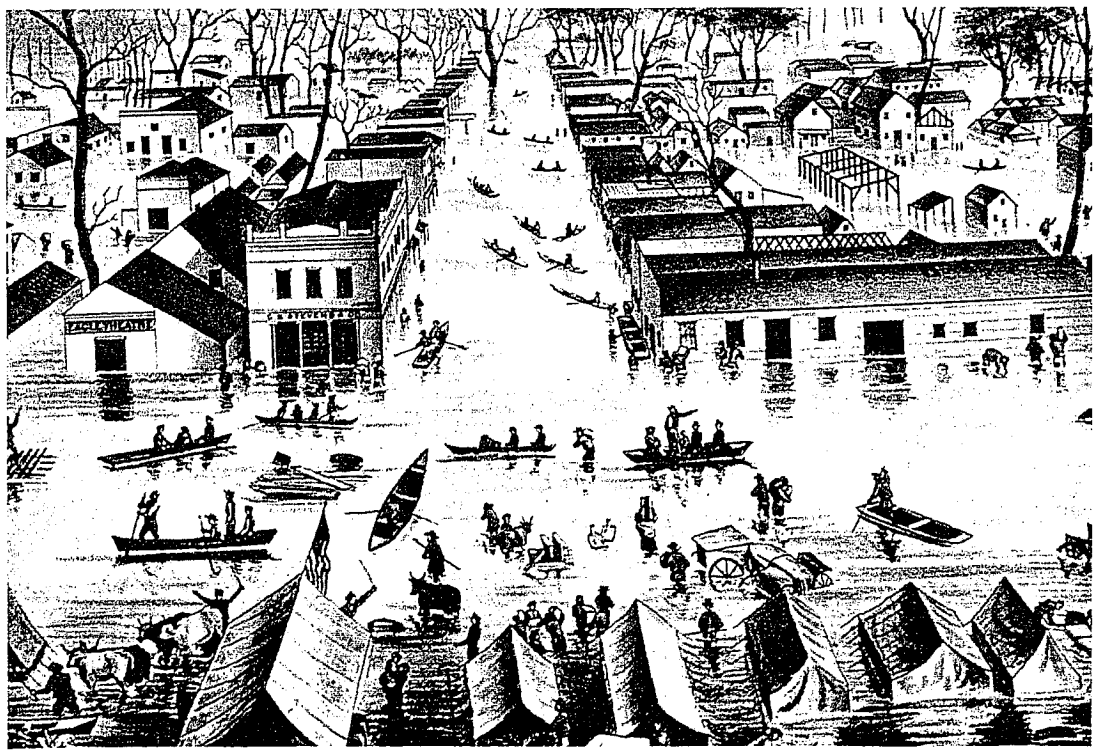
The first effort at flood management in California came with small levees built to protect the town of Sacramento from what American Indians called the "inland sea," caused by flood waters that often covered the valley in winter. Nineteenth century farmers in the Sacramento and San Joaquin valleys and the Delta constructed levees to protect farmland. The Central Valley, bordered by the Sierra Nevada on the east and the Coast Range on the west, has been called a large bowl that collects most of California's rainfall. The first gold miners poled flat-bottomed boats around the frequently flooded streets of Sacramento. During the Great Flood of 1862, parts of downtown Sacramento were underneath 20 feet of water.

Substantial government-sponsored flood management efforts did not begin until the late 1880s. The Yuba, Feather, American and Sacramento rivers, laden with sediment from hydraulic gold mining upstream, spilled over their banks and covered the Sacramento Valley. Hydraulic mining, which used canon-like monitors to shoot water at hills in the 19th century hunt for gold, ripped apart entire hillsides, choked the rivers with silt and intensified the effects of floods. Historian Robert Kelley in his book "Gold v. Grain" described hydraulic mining as "the best paying industrial development in the world." But the mountain mining's impact on the Central Valley, as Kelley noted, was considerable.

"None of the interior streams of California, though naturally as pure as crystal, escape the change to a thick yellow mud," said a newspaper of the era. "The Sacramento is worse than the Missouri."

Frightened by the ferocity of the floods, merchants, farmers and landowners combined forces and lobbied for flood management and improved river navigability. In 1884 Judge Lorenzo Sawyer of the federal Ninth Circuit Court in San Francisco delivered a 225-page ruling that prohibited any mining debris in the rivers. The "Sawyer Decision" effectively shut down hydraulic mining within a matter of years. The farmers won. Church bells rang in Marysville, a bonfire was lit and a band marched. "You can have a big time," an attorney opposing hydraulic mining wired the president of an anti-mining debris association. "Success attends us at every point."

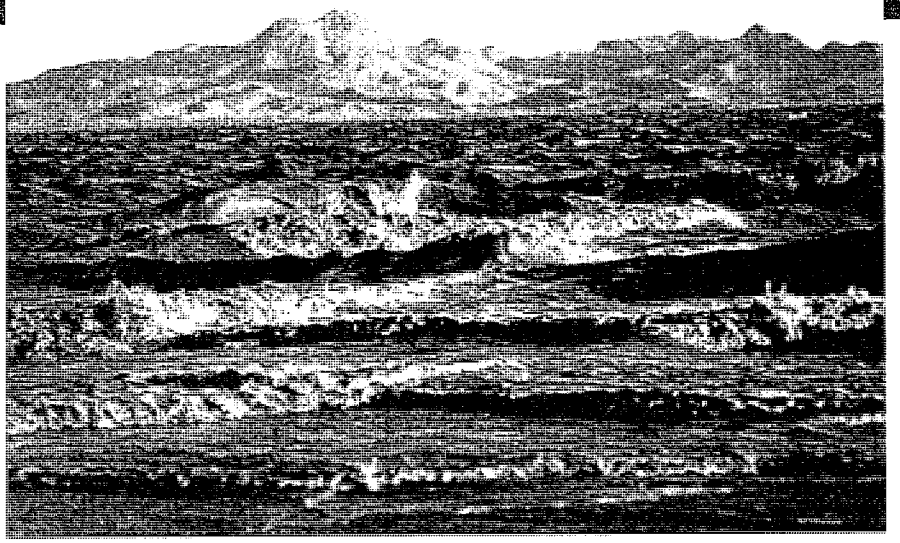
In 1893, Congress created the federal California Debris Commission to look into debris-related flood and navigation issues, primarily in the Sacramento Valley. The commission's investigations uncovered a viable flood management plan devised in 1880 by State Engineer William Hammond Hall. The plan was subsequently modified through citizen input to include a system of levees, weirs and bypass channels to improve navigability and protect population centers in the Sacramento Valley. In 1911 the State Reclamation Board (now the Central Valley Flood Protection Board) was created to implement this plan. After a series of flood years in the Sacramento Valley, congressional authority for the Sacramento River Flood Control Project finally was granted in 1917. Engineers



designing the project based their calculations on the 1907 and 1909 floods, which were later estimated to have had a one-in-25 probability of occurring in a given year.

In 1920 Col. Robert Marshall, chief geographer for the United States Geological Survey, proposed a major water storage and conveyance plan to transfer water from Northern California to meet agricultural and urban needs of Central and Southern California. This plan ultimately provided the framework for development of the federal Central Valley Project (CVP), which today is one of the largest water storage and transport systems in the world that runs from Lake Shasta in Northern California to Bakersfield in the southern San Joaquin Valley. Through a massive system of reservoirs and canals, the CVP delivers about 7 million acre-feet of water during a normal precipitation year.

As part of the CVP, Folsom Dam on the American River was originally authorized for construction by the U.S. Army Corps of Engineers (Corps) in 1944 as a flood management facility for the Sacramento Valley – located at the confluence of the American and the Sacramento rivers – which has flooded countless times over the centuries. The dam was completed in 1956, and is credited with providing flood protection for the valley during major floods in 1964, 1986 and 1997.



A combination of levees, dams, storage reservoirs, bypass channels and overflow weirs protect Central Valley lives and property from seasonal flooding.

Through the years, while earlier flood management structures were being built, public safety and protection against flood damage were the highest priorities; environmental issues were not considered. More recently, however, society has emphasized the importance of preserving fish, wildlife and habitat. In addition, flood managers have learned many activities that severely modified landscapes have increased runoff and aggravated flood damage. As a result, flood management projects face more scrutiny and are more complicated in order to meet many goals.

Levees

The thousands of miles of levees, both public and private, built since the mid-19th century to help contain larger streams and rivers are a major flood management feature throughout California and the West.

Within the Central Valley, responsibility for levee maintenance is spread among three governmental levels. After the Corps completes a congressionally authorized levee construction project, maintenance responsibility is turned over to the Central Valley Flood Protection Board which passes this responsibility on to a local agency. The Central Valley Flood Protection Board controls encroachments through its regulatory authority over federal levees, and DWR performs inspections.

However, after Gov. Schwarzenegger declared a flood emergency in early 2006, DWR and the Corps repaired 116 critically damaged sites – totaling about 10 miles of repairs – in about three years.

Overtopping, seepage, instability or erosion can cause levee failures. Because many levees were deliberately built close to the river channel to help scour mining debris from rivers, erosion has become a major problem. State officials say a substantial backlog of erosion repair work exists and that the problem is complicated by the need to adhere to environmental safeguards.

The waterside surface of levees is often covered with layers of rocks, known as riprap, to protect them from erosion, while vegetation is periodically cleared to prevent decreased channel flow and ease inspections. With concern over the loss of riparian habitat and the wildlife it sustains, flood management officials have allowed vegetation to grow on riprap in selected locations.

In 2007 the Corps sought more rigorous enforcement of existing levee maintenance standards, which called for removing wild growth, trees and other encroachments that might impair levee integrity. But other agencies and environmental organizations noted levee slopes in California's Central Valley often contain brush and trees that are the last remnants of a vast riparian forest that once extended across the valley floor next to the Sacramento and San Joaquin rivers. Much of the remaining vegetation provides important benefits that the stricter enforcement of Corps regulations could impact.

2,818 miles of underground storm drains and more than 78,500 inlets and catch basins.

The structures were constructed because flash floods are common in Southern California. These floods are smaller, localized and of high intensity. On New Year's Day in 1934, 40 people died in a flash flood near Glendale. Four years later, in the county's most deadly flood, 113 people died when water roared through downtown Los Angeles with little warning. Floods in 1969 devastated northern Los Angeles and Ventura counties, killing 90 residents.

In Los Angeles County, $220 million in improvements, including the raising of 21 miles of levee and the modification of other stretches of the Los Angeles and Rio Hondo rivers, paid off in 2004-2005 when a series of storms dumped more than 35 inches of rain on the region without major damages.

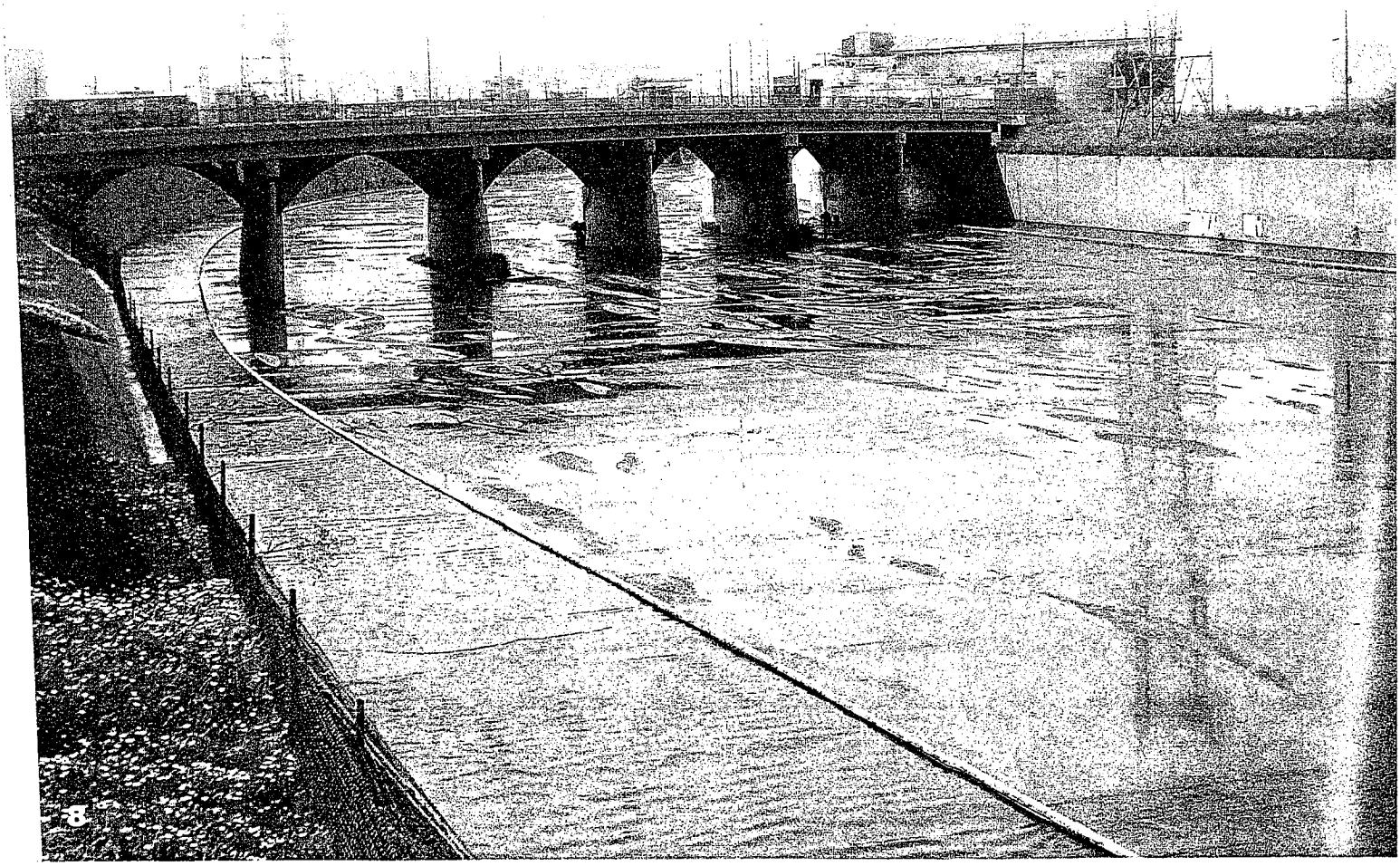
Other areas of the state also developed flood management systems. Hundreds of smaller dams, levees, channels and bypasses have been built throughout Southern California, from miles of channels on the Santa Ana River to protect areas of San Bernardino, Riverside and Orange counties to Quail Wash levees that protect the southern desert town of Joshua Tree.

The flood risk associated with the Santa Ana River was considered one of the most significant threats to development since the 1930s. In 1938, Orange County experienced California's worst flooding of the 20th century. In Anaheim, dozens of people died, flood waters reached 15 feet in some places and 182,000 acres were inundated. Realizing they were lacking adequate programs for flood protection, San Bernardino County and Riverside County created their flood management districts in 1939 and 1944, respectively.

To address the continued flooding threat, the federal Prado Dam – on the Santa Ana River near Corona in Riverside County – was authorized in 1936, but it was not completed until 1941. The dam was built primarily for downstream flood protection, constructed in a location where 92 percent of the watershed lies above it. More recently, the dam also has become a vital component of the water supply management program in the region, and has allowed the creation of ecologically important habitat areas behind the dam.

When Prado Dam was built, it was to provide protection against flooding in a 200-year event. The area since has become so heavily populated the dam offers protection against a 70-year event with downstream channel capacity reduced to protect against a 50-year event.

This channel in Los Angeles County is part of one of the largest flood control networks in the world.



North Coast Rivers

Along California's scenic North Coast, most rivers remain relatively undeveloped. The Klamath, Trinity, Eel, Russian and Smith rivers are the major waterways that drain this sparsely populated, forested area. Many of these rivers do not have reservoirs with dedicated flood protection space. In addition, portions of the Klamath, Trinity, Eel, Smith, Van Duzen, Salmon and Scott rivers are protected from future dams and diversions under state and federal wild and scenic rivers designations which also forbid bypasses, weirs or impoundments.

In 1955, discharges from the Klamath River were one and a half to two times greater than recorded peak flows. Peak flows were surpassed by more than 30 percent in 1964 on the Eel, Klamath and Smith rivers. In addition to the human fatalities, the Eel's flooding drowned more than 5,000 head of livestock and demolished 18 state bridges.

The Russian River is one of the most flood-prone rivers in California, routinely overflowing during wet years. As storm systems approach California, the wet bands of clouds are uplifted by the Coast Range, releasing precipitation first and most intensely on the coastal streams. One flood control dam is on the Russian River and one on Dry Creek, a tributary to the Russian River, which can capture about 20 percent of flood flows.

Guerneville originally was primarily a community of summer homes, but full time residents began moving into the area in the 1960s, increasing the impact of seasonal floods. In 1986, 1,000 residents along the banks of the Russian River were evacuated because of flooding when the river crested at 49.1 feet, more than 17 feet above flood stage.

In 1995 the Russian River broke through private levees along a 10-mile stretch of the Middle Reach section and inundated a series of gravel pits, including a 72-acre pit used for storage of Healdsburg's secondarily treated sewage. Inundation of these pits threatened to permanently change the course of the river and damage water supplies and fisheries.

In 1997, the swollen Russian River crested at approximately 44 feet at Guerneville, 12 feet above flood stage. Flood water inundated numerous homes and businesses.

A project underway on the Napa River – which has endured 27 major floods since 1862, including a levee break in 1997 – involves a "living river" design to protect a stretch of 6 miles running through the city of Napa. The Napa County Flood Control & Water Conservation District notes that pastureland at the downstream end of the project was returned to a wetland environment that can hold excess water. Old bridges blocking flood flows were replaced. A dry bypass channel for an oxbow area creates a shortcut for fast-moving water that historically has resisted the sharp turns required by the natural geography.

Because the bypass will be used only when waters rise to flood stage, the oxbow will remain connected to the main channel, and preserve the habitat there. The plan had an original projected finish date of 2013 and relied on a one-half cent sales tax that would generate over $120 million over 20 years. In 2009 the project received a boost with $99 million of federal stimulus funding.

Heavy rains in Northern California during 1995 caused creeks to overflow and flood local communities.

Flood Management

California's flood management reservoirs provide more than 5 million acre-feet of seasonally reserved flood management storage, an amount that would cover the entire state to the depth of about one-half inch. In addition, there are more than 13,800 miles of public and private levees within the state.

Most dams and reservoirs provide water for more than one purpose, and these purposes often compete with each other. Water managers must keep enough reservoir storage space available to manage floods during the flood season but store enough water to protect against water shortages during the dry season. Like one water manager said: "The ideal for flood control is an empty reservoir; for water storage, a full reservoir." Additionally, water releases to benefit fish and wildlife have become increasingly important as have those for hydroelectric power generation.

In 1997, a flood on the San Joaquin River downstream from Friant Dam caused extensive damage.

Water releases from Central Valley dams augment naturally low or intermittent stream flows and repel salt water intrusion in the Delta during low outflow months. Water is released below some dams to mitigate the adverse impacts of the State Water Project and the Central Valley Project and to help spawning fish – including threatened and endangered species. Dams and reservoirs also provide recreational opportunities, including swimming, boating, and fishing where public health and safety allow.

No single formula can balance the competing needs of each project. Hydrologic conditions, including downstream channel capacities and terrain, vary sharply. Projects also operate within limits to achieve certain flood protection levels as well as define water supply, recreation and hydropower production objectives. Operational decisions at each dam are based on computer model simulations of historical storm analyses, statistical risks and downstream impacts. These criteria determine when and how much water is released from reservoirs during storms.

The Corps' regulations for multipurpose reservoirs in the Sacramento Valley require more storage space to be reserved for flood management during the late fall and winter months. Except for rare years of heavy snowpack in the northern Sierra, flood risk declines

during the spring. In the San Joaquin Valley, runoff is derived primarily from the southern Sierra snowpack and reservoir flood space may be maintained until early summer. As the need for flood space diminishes, reservoirs are filled with snow melt for use during California's long, dry summers.

Outflow from reservoirs is usually regulated by balancing the remaining reservoir storage space, the expectation of additional inflow and downstream flow rates. Some multipurpose dams are geared more toward flood management and others for water storage. The two needs sometimes collide.

Following the subtropical series of storms that hit California in January 1997, flood managers released record outflows from several reservoirs to avoid uncontrolled spills. The months following the floods were some of the driest on record. The reservoirs did not fill and Reclamation had to reduce water deliveries.

State and federal officials have recommended additional flood reservoirs. DWR is proposing the offstream Sites Reservoir project in Glenn and Colusa counties in Northern California. In addition, supporters of a new Temperance Flat Dam and reservoir on the San Joaquin River above Friant Dam, 25 miles northeast of Fresno, say the project would provide additional flood protection because Friant Dam/Millerton Reservoir has insufficient capacity to regulate runoff from the upstream watershed and can provide water for salmon restoration.

Key Agencies Involved in Flood Management

The **U.S. Army Corps of Engineers (Corps)** is the primary federal flood management agency. It develops guidelines for flood management storage in federally-funded reservoirs and monitors reservoir operations. The Corps also constructs flood management projects, operates multiple-purpose projects, and provides resources, equipment and personnel for emergency flood fights.

The **U.S. Bureau of Reclamation (Reclamation)** operates several multipurpose projects throughout the state, including the Central Valley Project (CVP) and the Colorado River system. The Bureau's flood hydrologists assist in interpreting flood-related data.

The **National Weather Service (NWS)** issues weather forecasts and flood warnings. It helps communities establish flood warning systems and conducts flood hazard analyses and provides other technical assistance.

The **Federal Emergency Management Agency (FEMA)** administers the National Flood Insurance Program (NFIP), disaster planning and recovery programs. FEMA works closely with states and communities and provides financial and technical assistance, flood hazard maps and data to better manage floodplains.

The **California Department of Water Resources (DWR)** operates the State Water Project (SWP), runs the state-federal Flood Operations Center and assists the NWS in flood forecasting. It is responsible for the operation and maintenance of the Sacramento and San Joaquin flood management projects. DWR funds flood management projects outside the Central Valley, carries out the state's floodplain management laws and coordinates the floodplain management aspects of FEMA in California.

The **Central Valley Flood Protection Board** cooperates with the Corps in the planning, construction, operation and maintenance of flood management projects in the Central Valley. Once a project is completed, the board holds the federal government harmless, accepts legal responsibility for its maintenance and then turns the maintenance responsibility over to a local agency or DWR. The board also controls, through a permitting process, activities and development in state designated floodways.

The **California Emergency Management Agency** may allocate funds for investigation, estimates, reports and repairs regarding disaster recovery financial assistance for flood management works that do not come under the provisions of another authority. It administers FEMA's hazard mitigation program in California.

The state also has many local flood management agencies responsible for the day-to-day operations and maintenance of facilities, development and implementation of flood management and storm water drainage plans, and coordination with other state and federal agencies.

Floodplains

Development is widespread on many floodplains. Large parts of California's valleys are historic floodplains – low areas adjacent to waterways that flood during wet years. Urban areas developed here because rivers were the main routes of commerce. In addition, floodplains often contain the best soils for agricultural crops because overflowing rivers leave behind layers of silt and topsoil. However, despite levees and upstream dams, floods in these vulnerable areas have caused billions of dollars in damage.

Congress established the National Flood Insurance Program (NFIP) with passage of the National Flood Insurance Act of 1968. Regular homeowner insurance typically does not cover flooding, and this measure allows property owners to buy insurance as protection against flood losses once the affected community establishes regulations to reduce the potential for future flood damages. This insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods.

The Department of Homeland Security's Federal Emergency Management Agency (FEMA) is required by statute to identify and map the nation's flood-prone areas and establish flood-risk zones in such areas. Flood hazard maps have been issued for more than 19,200 communities. To date, flood map panels have been produced depicting approximately 150,000 square miles of floodplain areas. FEMA flood maps can be accessed online at http://www.fema.gov/hazard/map/index.shtm

FEMA's maps are seen as an essential tool for flood hazard mitigation. The newer maps convert flood hazard data from a paper map system to a digital format that will create a community-level Geographic information System (GIS) tool so that users may access and store data for a variety of natural and manmade hazards.

Yet, questions arose about the adequacy of the 100-year flood designation after the 1997 floods in the Central Valley. Critics said the maps did not adequately depict areas reasonably likely to flood and do not incorporate the effects of upstream development, which rapidly pushes runoff to downstream areas.

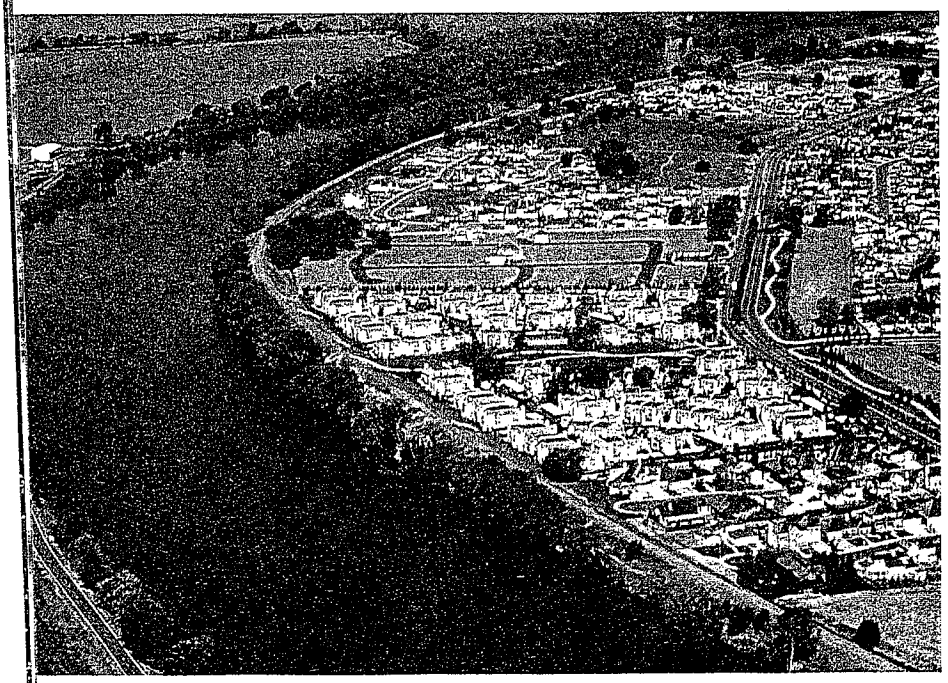
In the 2004-2005 budget analysis prepared by the state Legislative Analyst's Office (LAO), it was also noted that FEMA's mapping activities had not kept pace with changing conditions in California. The LAO noted that while DWR estimates that at least 50,000 of the state's 200,000 miles of streams will likely see development during the next 20 years, FEMA has mapped only 15,000 miles the past 30 years. The state has attempted to fill the gap through its own mapping program, which, while not as detailed as FEMA's, does include analysis of areas outside of FEMA's designation of areas prone to a 100-year flood that may be at risk.

In addition to FEMA's flood mapping efforts, in 1992 Congress created "AR Zones," flood management restoration areas based on 100-year floodplains where levee restoration is underway. The designation can affect flood insurance rates and the design of new structures, but may not preclude new development. Eligibility for the AR Zone is determined by the flood protection system being deemed restorable by a federal agency. FEMA can make such a designation if a minimum level of flood protection is still provided – and if restoration of the flood protection system is scheduled to occur within a set time and following a progress plan negotiated between the community and FEMA.

FEMA then prepares a revised flood map with AR Zones and any previous underlying flood hazard zones. Specific minimum levels of elevation are required of the lowest floor of new and substantially improved buildings, depending on flood depths. Mandatory flood insurance purchase requirements apply. To remove the AR Zone designation and show the restored flood management system as providing 100-year flood protection, communities are required to have completed restoration or to have shown adequate progress toward completion.

One metropolitan area where flood mapping has been the target of discussion is flood-prone Sacramento. Following the 1986 floods, the Corps had reassessed the adequacy of the local levee system and estimated that a 100-year flood along the American River floodplain could cause up to $15 billion in damages and cost as many as 100 lives. In 1989, FEMA mapped most of Sacramento

Aerial view of levees and housing developments along the Sacramento River. These homes are protected by the coordinated efforts of many local, state and federal flood control agencies.



into the 100-year floodplain. Much of the Natomas area, consisting of 86 square miles of land near the Sacramento International Airport and targeted for new development, was also included in the revised FEMA floodplain.

Beginning in 1990, extensive levee repair and upgrades were carried out along the Sacramento and American rivers to increase protection to a 100-year level. These upgrades, along with reoperation of Folsom Dam and reservoir to include more interim flood management storage, led the Corps to certify the Natomas basin levees for 100-year flood protection in 1998. FEMA then mapped the area out of the 100-year floodplain, opening the area for new development.

Other projects to address levee underseepage and erosion concerns allowed the Corps to certify most of the remainder of Sacramento's levees for 100-year protection. Areas still within the 100-year floodplain include the South Sacramento and Pocket areas, the Mayhew area, and areas affected by local streams and storm drainage issues.

In addition, new levee design requirements adopted by the Corps in 2004 lowered the Natomas area's level of protection to less than the 100-year benchmark. Local flood protection entities are attempting to expedite several projects to increase this level of protection using state, local and private funds.

Yet the Corps had been concerned about conditions of Central Valley levees during 1997 high water and began investigation of Natomas levee stability. Soil borings in 2000 and 2001 showed serious threat of levee failure due to underseepage. As a result of additional borings and evaluation by SAFCA, in 2006, the Corps said it could no longer support its 1998 certification of the Natomas levee system, and told the city of Sacramento that levees protecting the Basin against flooding from Sacramento and American rivers didn't meet 100-year flood protection standard.

Near the end of 2006, DWR advised the city that the Natomas area was at high risk and urged voluntary adoption of limits on new construction until the levees are upgraded.

The Natomas Levee Improvement Program in the Sacramento area seeks urban-standard 200-year flood protection for developed areas in Sacramento's major floodplains over time. The work intends to provide at least 100-year flood protection as quickly as possible and lay the groundwork for 200-year flood protection, according to the Sacramento Area Flood Control Agency (SAFCA).

Achieving goals of the Natomas Levee Improvement Program would significantly reduce the risk of an uncontrolled flood in the Basin that would result in the catastrophic loss of property – estimated at $7 billion – and a prolonged interruption of commercial activity, according to an Environmental Impact Report. That interruption would include operation of the Sacramento International Airport and closing Interstate 5 and State Route 99.

The city of Sacramento in June 2007 asked FEMA to revise its flood insurance rate map for the Natomas Basin. Since SAFCA began its goal of 200-year flood protection for the city, the flood control agency worked with the Corps and the state to restore 100-year flood protection for most of the Sacramento urban area, the city said. More than $460 million had been spent on levee improvements.

Development plans for the Natomas Basin were dealt a setback in the fall of 2007 when FEMA turned down the city of Sacramento's request for a Zone A99 flood designation which would allow development to continue without restrictions. In its notice to the city FEMA stated that the Corps had de-certified levees because of inadequate freeboard and underseepage protection. The city's submittal insufficiently documented progress on the work of these critical features. Instead, much of the money was spent on design activities and erosion control work, according to FEMA.

North of Natomas, questions about floodplain development also were raised in Yuba County along the Sacramento River's tributaries. In 1993 local leaders approved a 12,000 home development in an area considered at risk from flooding. The approval was based in part upon several existing projects meant to shore up levees along parts of the Feather, Yuba and Bear rivers. Construction began in 2004, seven years after the 1997 flood that deeply inundated the area, and after tens of millions of dollars were spent on planning and constructing flood protection projects. A $480 million project is under consideration by the Three Rivers Levee Improvement Authority, which was created in 2004 to finance and build levee improvements in Yuba County.

Supporters of development in Yuba County – which has not shared in the economic boom of the state – defend building by arguing that the construction helps fund needed levees.

Based on a mapping study of the Lower Feather River Floodplain, DWR aims to have FEMA designate large sections of Yuba and Sutter counties in the less than 100-year floodplain. Such action could increase flood insurance premiums and make it more difficult to build in some areas where structures would have to be raised. Yuba County officials fear the designation would halt development and a planned $60 million levee-improvement program.

State Liability

Liability for levee failure took a new turn after a court ruling found the state liable for hundreds of millions of dollars from the 1986 Linda Levee collapse in Yuba County that killed two people and destroyed or damaged about 3,000 homes. The court found that "when a public entity operates a flood management system built by someone else, it accepts liability as if it had planned and built the system itself."

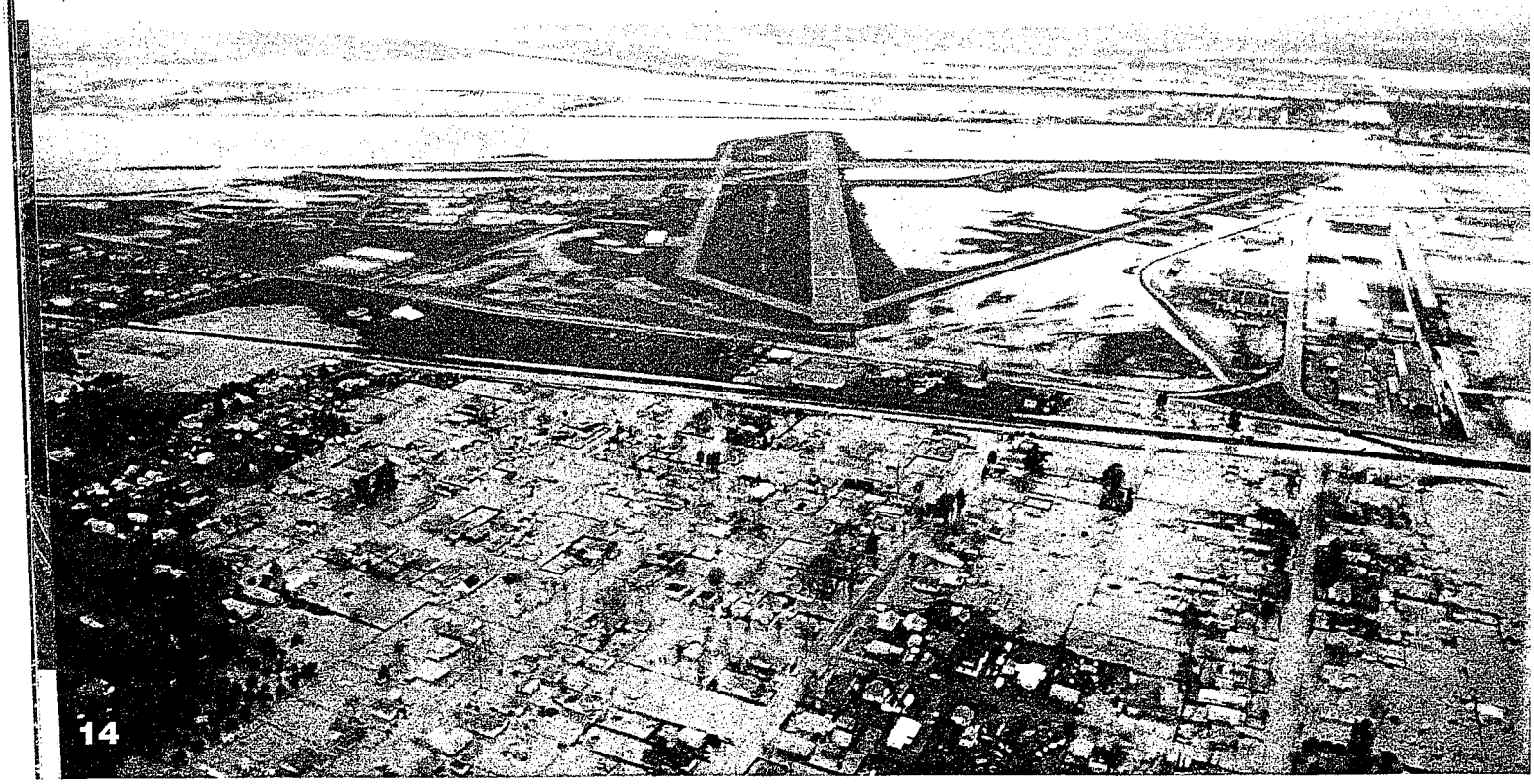
The lawsuit against the state of California first went to trial in 1991, resulted in an appeal, then a second trial in 2001. In 2003, the *Paterno v. State of California* ruling by the Sacramento-based Third Appellate District Court determined that the state accepted the Linda Levee as built "without any measures to ensure it met design standards." The court ruling involved some 3,000 plaintiffs and found the state liable for potentially hundreds of millions of dollars. The state by 2007 had paid $464 million in the case, according to DWR.

The *Paterno v. State of California* decision prompted state officials to undertake a comprehensive review of the state's liability regarding levees in advance of a legislative briefing. Opinions regarding the case's significance vary. For the plaintiffs, the legal findings vindicated their claim the state failed to make repairs to a levee that was a known weak spot. They say the state knew of the levee's weakness but did not act to improve it. But others dispute that, saying that the levee was thought to be in good condition.

Some faulted the court for not completely accounting for the levee's flawed design and cautioned the decision could make the state reluctant to involve itself in flood management projects because of the financial exposure. Legal experts also criticized the ruling for framing levees as an inherent risk rather than a benefit to those protected.

Governmental liability for levee failure also occurred in 2002 when an appellate court found Monterey County, Santa Cruz County and the state Department of Transportation liable for the damage from a 1995 flood that overwhelmed levees on the Pajaro River near Watsonville. The two California counties and the state Department of Transportation (Caltrans) paid $51 million in the case.

The counties claimed they faced restrictions from regulatory agencies in cleaning out vegetation in the flood channel, but the court ruled that the counties hadn't tried hard enough. The chain of levee failures and subsequent liability claims has prompted some in the flood management community to dub the situation a "liability crisis," since judgments appear to be turning toward the standard of strict liability.



The Linda Levee collapse in 1986 led to lawsuits and a landmark court ruling that established government liability for levee failures.

Floodplain Protection

Flood management seeks to prevent deaths and minimize property damage through structural and non-structural approaches. The structural approach, typically necessary in urbanized areas, uses dams, reservoirs, levees and bypass channels to confine and direct flood flows away from people and property.

The nonstructural method applies management principles to better manage flood risks. These include mapping historic floodplains, limiting land development within them and implementing special building codes, insurance and public outreach. It also may include the intentional flooding of low-lying areas to relieve pressure – reduce the velocity and quantity of flow – farther down the stream.

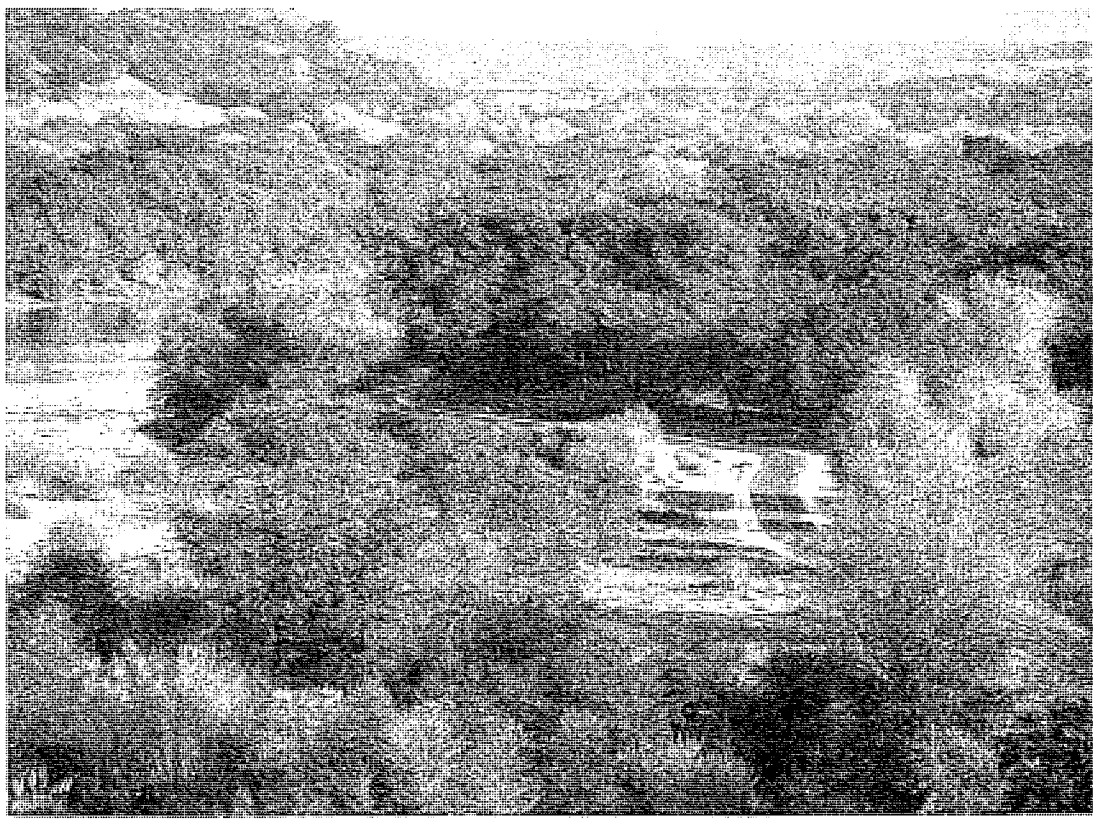
In 2002, an interim comprehensive study jointly prepared by the Corps and the Central Valley Flood Protection Board declared that "population increases, urban expansion into agricultural areas ... and continued degradation of riverine ecosystems placed demands on the system that were not originally anticipated.

"The original flood management system ... was visionary in its ability to convey large floods with minimal damage," the study said. "Reflecting public values and attitudes at the time it was developed in the early 1900s, [it] was based upon managing and redirecting flood flows so that land could be put to a higher economic use rather than managing land uses and accepting the fact that flooding will occur."

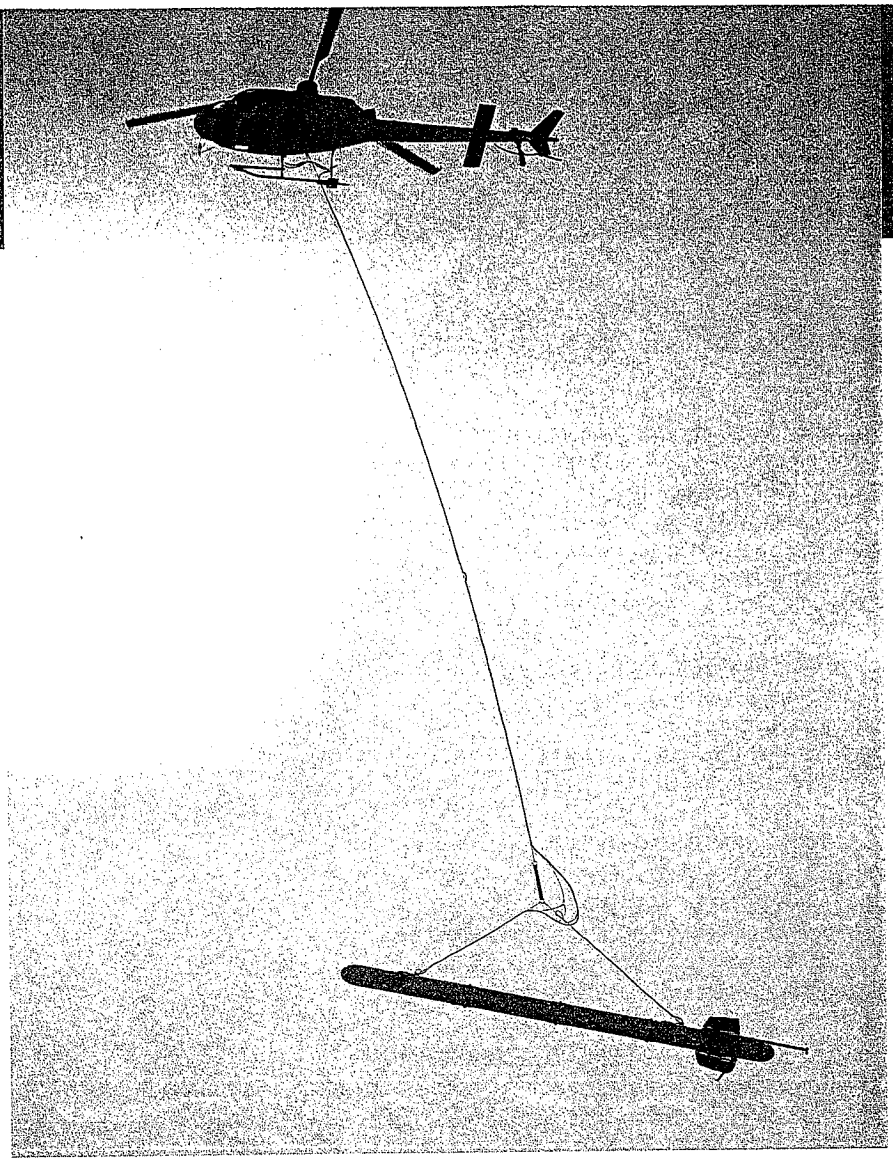
The study laid important groundwork for the Board's involvement in local multi-objective improvement projects such as is occurring in Hamilton City, west of Chico. There, plans are underway to set back several miles of levee to allow some floodplain restoration while also preserving land for agricultural production and providing improved protection for local residents.

DWR noted in 2007 that its criteria for early implementation projects emphasize building setback levees and other non-structural approaches to flood management when feasible. Expanded channel conveyance and in-channel flood storage was also emphasized.

What's been called the "soft path" to flood management calls for reducing development in flood-prone areas and working with the forces of nature. The "living river" in Napa is an example of such an approach (see Page 9). Setback levees are being looked at in Central Valley communities not only to replace aging levees but as a means to create new ecosystem habitat. Currently, the Three Rivers Levee Improvement Authority plans to set back six miles of levee on the Feather River west of Arboga, including a section that collapsed during the 1997 floods.



The bike paths and parks within the American River's floodplain in Sacramento are designed to accommodate both seasonal flood flows and recreational use.



Helicopter surveys using electromagnetic sensory technology were conducted in 2007 along levee systems that provide critical flood protection for the urban areas of Marysville and Yuba City as well as Stockton and Lathrop.

In 2007 Gov. Schwarzenegger signed flood management legislation that included reforming the Central Valley Flood Protection Board to improve transparency, require cities and counties to increase consideration of flood risks when making land use decisions and create a new 200-year standard in flood protection for urban development in the Central Valley.

New laws in 2007 also included measures requiring cities and counties to address flood-related matters in land use, conservation, safety and housing elements of their general plans. Other requirements included development of a Central Valley Flood Protection Plan by Jan. 1, 2012.

In Southern California, the flood management system historically served one primary purpose - to swiftly carry stormwater away from urban areas to the ocean. The system has effectively served this purpose, but there is a new way of thinking being adopted by flood management agencies to address flood protection in a more holistic, environmentally sensitive manner. Agencies and environmental organizations are working together to address water resource projects with multiple objectives by taking a watershed approach to managing stormwater. This approach considers a range of issues including water quality, water conservation, habitat value, open space, recreation, and other natural resource and public use functions.

The majority of Los Angeles' flood management projects were constructed by the Corps between 1934 and 1970, and today the Corps is updating the system under the $217 million Los Angeles County Drainage Area (LACDA) project. As part of this project the Corps and the Department of Public Works effectively incorporated native landscaping improvements and a regional recreational trail system.

River greenway improvements have been a strong focus for agencies and activists in the past 10 years. With the scarcity of park space within the urban areas of Southern California, flood water channels provide an opportunity for multi-use recreational corridors. In 1996, the Los Angeles River Master Plan was adopted and created a vision of greenways and recreational pathways along the 51-mile Los Angeles River and nine-mile Tujunga Wash. Since then, the plan has seen more than $100 million of projects implemented along its river corridors, providing a variety of watershed improvements while retaining the system's primary function of flood protection.

Interest is growing to restore many concrete-lined channels to a more natural state, thereby improving water quality, increasing groundwater recharge, and creating habitat. Because of intense urbanization and the proximity of development, the complete removal of concrete in many urban rivers may not be feasible. However, agencies and organizations are investigating areas where stream restoration could be a reality.

Statewide, new development principles also are in play. Low Impact Development (LID) rejects traditional notions of stormwater management to convey drainage off-site as quickly as possible. LID instead infiltrates, filters and stores stormwater. The approach seeks to maintain existing hydrology and reduce clearing and grading, minimizing extensive drainage systems that carry runoff to waterways. Some builders, citing higher design and construction costs, question whether LID is cost-effective.

Supporters of the new principles say that retaining stormwater can boost groundwater supplies. The Los Angeles Basin, where intense storms can strike, sits in the path of powerful fast-moving runoff from the Santa Monica and San Gabriel mountains. Engineers, recognizing the city's vulnerability to flooding, designed a system that rapidly sends most storm flows through concrete channels to ocean outfalls. The Los Angeles and San Gabriel Rivers Watershed Council is looking at directing additional stormwater flows to sites where groundwater aquifers are slowly filled through infiltration.

Levees

Delta Levees

Nowhere in California is the levee system more extensive or more tenuous than in the Sacramento-San Joaquin Delta. The Delta is an integral part of a natural ecosystem that has been extensively modified for agriculture and to irrigate 2 million acres of farmland in the San Joaquin Valley and deliver part of the water to meet the needs of 22 million people – two-thirds of the state's population.

There are approximately 1,100 miles of levees – most of which are privately owned – protecting 700,000 acres of lowland in the Sacramento-San Joaquin Delta. In the Suisun Marsh, there are approximately 230 miles of levees protecting over 50,000 acres of marshland.

Only about a third of the Delta levees (385 miles) are part of a federal flood management project of the Sacramento and San Joaquin River systems and, as a result, are eligible for rehabilitation by the Corps. The vast majority of the levees – more than 730 miles and all of the Suisun Marsh levees – are local levees. These local levees were constructed and maintained during the past 130 years by local reclamation districts. In general, the levee work has been financed by the landowners within the levees. In the last 30 years or so, the state of California has provided supplemental financing for levee maintenance and emergency response.

Delta levees are distinguished from river levees in that they are constantly holding back water, making them more comparable to dams. Unlike dams, however, Delta levees were not constructed with strict engineering standards to withstand the constant pressure of water from the daily cycle of tides, wind and boat wakes.

Levee managers are not only plagued by levee breaks but also by the subsidence of the levees and Delta islands. Many of the central and western Delta islands contain rich organic peat soil that is being lost through oxidation, blowing away and compaction, lowering the island floors by as much as 2 inches to 3 inches per year and weakening the levees. Some areas are now more than 20 feet below sea level.

Levee maintenance is crucial to the state's water supply. A levee break near Isleton in June 1972 allowed large volumes of brackish water from San Francisco Bay to rush into the Delta, curtailing state and federal export operations. Approximately 300,000 acre-feet of fresh water was released from upstream reservoirs to help flush the intruding salt water out of the Delta.

Damage done by the 1972 flood prompted the California Legislature to fund the rebuilding and strengthening of numerous non-federal levees. Though the condition of the Delta levees has improved, as evidenced by fewer failures, they are still in need of work. In 1973, the Legislature passed the "Way Bill," and later the Delta Levee Flood Protection Act (SB 34), which allocated $120 million during a 10-year period. Since that time, additional legislation and bonds have raised the state contribution to Delta improvements to more than $160 million. The money was divided between the Delta Levee Subventions Program (a state cost-sharing program) and Delta Special Flood Management Projects. Under the subventions program, upon approval by the Central Valley Flood Protection Board, local agencies are compensated up to 75 percent for eligible levee maintenance costs and improvements in excess of $1,000/mile minimum expense.

Water from the Middle River pours into the Upper and Lower Jones Tract after the Delta island's levee broke in June 2004.

The levee improvement measures achieved under the program are credited with minimizing damage to Delta levees during the January 1997 floods. There were considerable concerns in 1997 about the massive flows surging into the Delta from the Sacramento and San Joaquin rivers that pounded the levees. Anxiety increased as the highest tides of the year washed in from San Francisco Bay at the height of the flooding, raising the water level and slowing the outflow of the floodwaters, further stressing the levees. But overall, most of the levees held.

Levee breaks are not limited to storms. On June 3, 2004 a 19-square mile area 10 miles west of Stockton was inundated after part of the levee protecting Upper Jones Tract unexpectedly gave way. When pump-out operations began a month later, approximately 140,000 acre-feet of water covered the 12,000 acres of Upper and Lower Jones Tracts to an average depth of about 12 feet. Total costs related to the levee break were estimated at about $90 million, including millions of dollars in direct flood fighting and levee-repair costs, and millions more in losses of crops and property. The value of the railroad track and Mokelumne Aqueduct that cross the island alone was estimated at more than $500 million.

An analysis of the Delta's vulnerability prepared by DRMS revealed a better than 60 percent chance that a natural event such as a big earthquake or major flooding in the Delta will cause multiple levees to fail simultaneously in the next 50 years, especially in the western and central Delta. Repairing the damage would take years, if it could be completed at all, given the cost and the fact that there is only one contractor in California currently doing such work. Widespread flooding could force a long-term shutdown of the SWP/CVP pumps that keep much of California supplied with water. Delta levees also protect an extensive network of public utilities (pipelines, highways, rail lines), preserve extensive farmland and facilitate significant recreational opportunities.

A final report of the first phase of DRMS released in the spring of 2009 noted that risk from Delta levee failures "are already high and are increasing." The report also did not identify any "significant risk factor" that would decrease the likelihood of Delta levee failures.

Not everyone agrees with the information released by DRMS. Critics say that the science comes without caveats or clarifications, fails to state how much data is still needed and doesn't make recommendations about next steps to correct the problems. It is premature to use the DRMS study in making final policy decisions, they say.

Yet, one thing that everyone involved with the issue can agree upon is that the fixes are costly. Estimates are at least $1 billion, although it has been pointed out that strengthening levees is not the same as reinforcing them against a major earthquake. Seismic upgrades would cost millions of dollars.

Federal and state crews repair and strengthen Delta levees broken and weakened by surging flood waters.

Rethinking Levee Construction

Levees along constricted rivers can pose major problems. The San Joaquin River levees, planned and designed in the 1950s, were designed to provide a lower level of protection because they were guarding agricultural areas and not developed housing. Also, this system was designed to convey spring snowmelt flows, which historically have been the critical flows in the river. Thus, a high level of protection was not deemed economically justified. In 1997, levees overwhelmed by high flows caused flooding in parts of Fresno, Madera and Manteca, and Stanislaus and San Joaquin counties – all areas with increasing urban development.

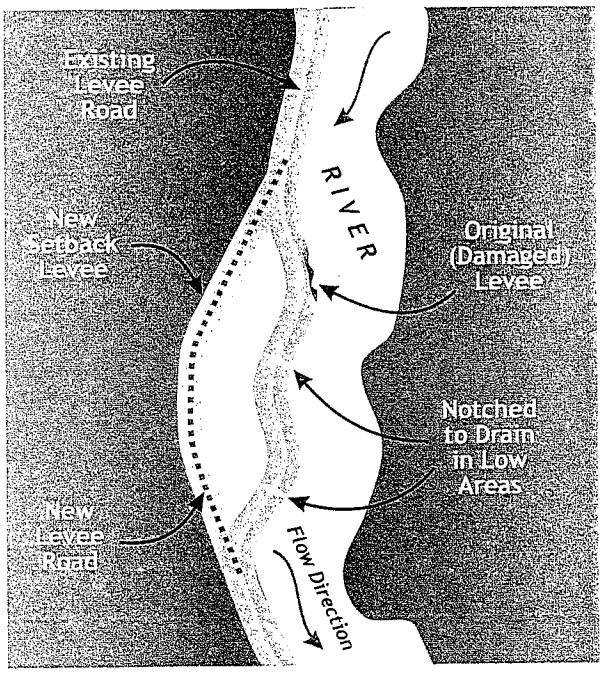
Riprap – lining stream banks and levees with rocks to stabilize them and deflect the impact of water - is the primary and most economical means of levee erosion protection in certain built-up areas. For years, the practice continued without attracting much attention. Yet environmental criticism has mounted, focusing on the impacts that excessive use of rocks have on natural morphology and habitat on the banks.

As an effective alternative, planners have begun to examine setback levees which are placed back from the river, allowing the river to meander. To build a setback levee, construction crews typically haul in tons of clay-like fill, build the new levee and abandon the old one. Engineers say it typically costs $20 million per mile to relocate a stretch of levee. Project sponsors must conduct hydrologic studies and demonstrate they won't significantly raise water levels downstream by removing a bottleneck in their floodway.

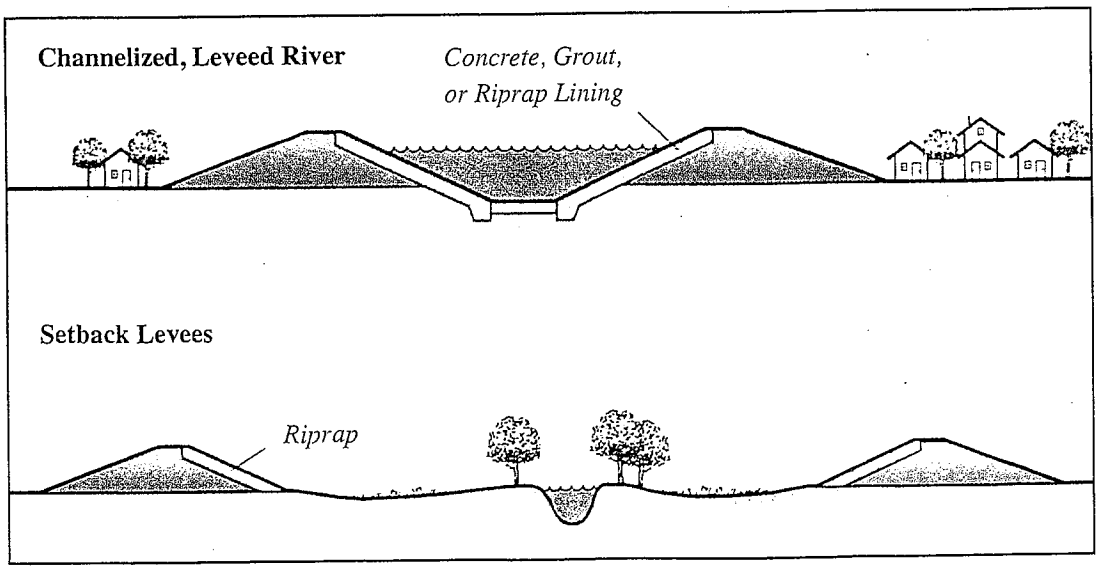
Statewide, the necessities of levee maintenance have collided with the need to protect the environment and endangered species, a predicament that has caused measures of frustration and confusion between agencies, and a sense by some that protecting lives and property has taken a back seat to environmental protection.

California Department of Fish and Game officials deny that environmental regulations inhibit the execution of sound flood management efforts because typically flood flows move through established waterways. Regulators encourage flood managers to consider the natural ecosystem, which features floodplains, in their work.

The Cosumnes River Preserve is a good example. The Cosumnes River is only 80 miles long with headwaters in the El Dorado National Forest at more than 8,000 feet above sea level. As the only remaining unregulated river on the western slope of the Sierra Nevada, the river experiences regular winter and spring overbank flooding as rain and snowmelt flow from the Sierra Nevada to the Central Valley. This promotes the growth of native vegetation and the



A setback levee allows the river to occupy the floodplain and reduces the threat of levees over-topping. The design of a setback levee varies depending on whether it is a delta, river or tidal levee.



wildlife dependent on those habitats. In 1997, miles of levees were intentionally breached and abandoned at the Cosumnes River Preserve to widen the floodplain and floodway to improve riparian habitat and increase flood protection.

The result is now a preserve that includes 46,000 of acres of wetlands and adjacent uplands. Considered one of the state's significant natural areas, it is home to more than 250 bird species, more than 40 fish species, and some 230 plant species.

Flood Planning and Improvement Initiatives

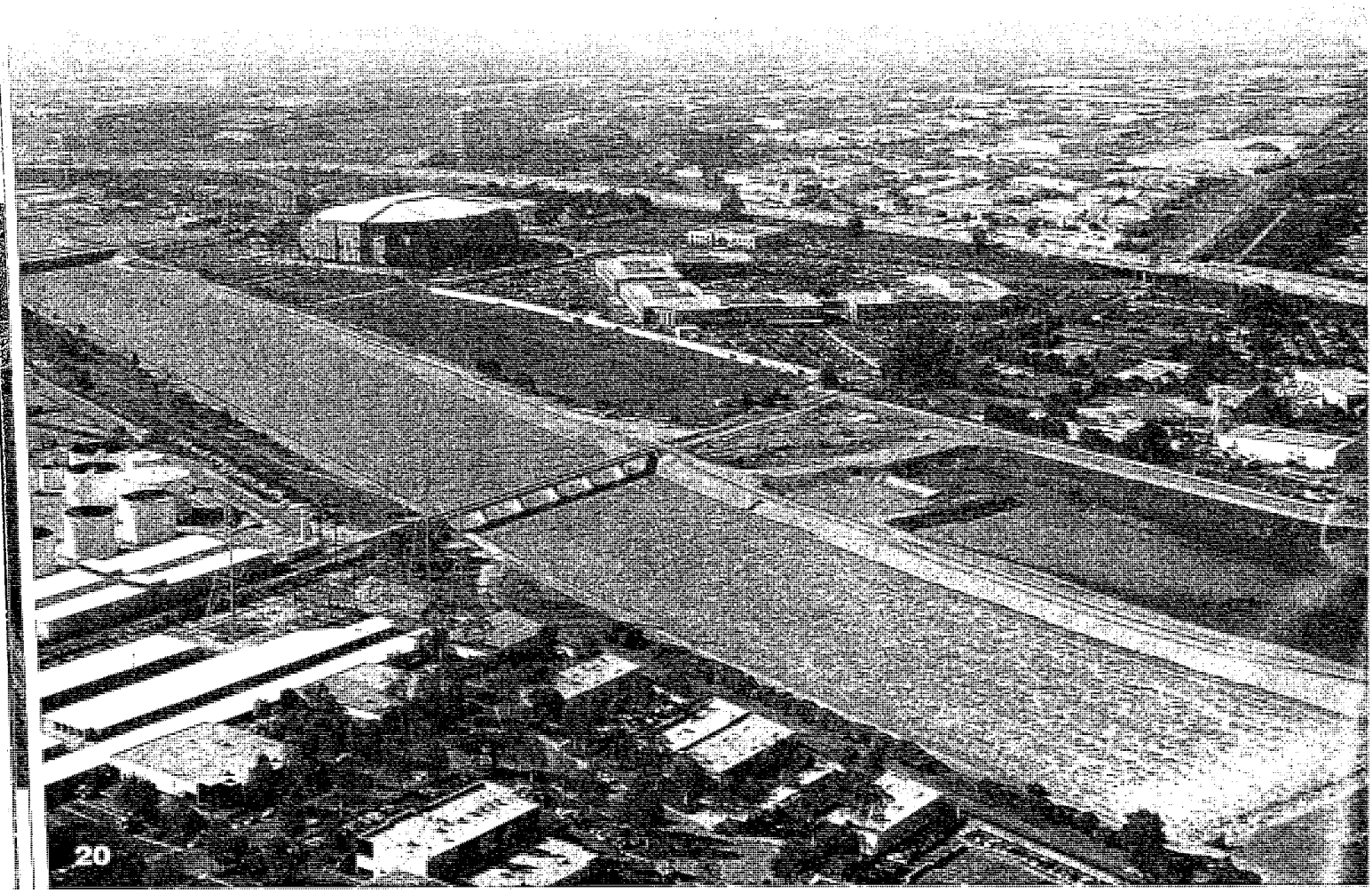
In November 2006 California voters approved Proposition 1E and Proposition 84, which provided a $4 billion general obligation bond to pay for work including levee repairs in the Delta and Central Valley, improved flood protection for cities and stormwater flood projects.

In 2007 a group of flood laws (Senate Bills 5, 17, 276, and Assembly Bills 5, 70, 156, 162 and 930) essentially rewrote the rules for flood management in the Central Valley. This included measures requiring cities and counties to address flood-related matters in land use, conservation, safety and housing elements of their general plans. Other requirements included development of a Central Valley Flood Protection Plan by 2012. The plan is being coordinated with the Corps under its Sacramento-San Joaquin River Comprehensive Study authority.

As part of this reform, cities and counties are required to increase consideration of flood risks when making land use decisions and create a new 200-year standard in flood protection for urban development in the Central Valley.

For example, SAFCA's Consolidated Capital Assessment District was formed in April 2007, and the creation of SAFCA's new Development Impact Fee Program took effect in May 2008. The assessment district is designed to provide the local share for the entire 200-year flood protection plan for the Sacramento area and raises $654 million over 30 years to cover increased maintenance costs, debt service on three separate bond issues and direct payments for flood control planning and construction.

A $1.3 billion project is underway to protect urban development near the Santa Ana River in Southern California.



Flood Forecasting

Predicting the weather is an unsure science but enhanced computers that analyze data have improved the accuracy of short-term weather forecasts. Long-term forecasts (30 to 90 days in advance) usually are limited to general terms such as "wetter than normal," as opposed to stating specific weather events. Long-term forecasts are about 55 percent accurate.

Flood control managers, however, often are able to predict with a high degree of accuracy when local flooding is likely to take place. Their forecasts combine storm runoff from unregulated tributaries with reservoir releases to predict river levels. In Northern California the National Weather Service (NWS), in cooperation with DWR's Division of Flood Management at the California-Nevada River Forecast Center in Sacramento, forecasts flooding. Federal and state hydrologists can estimate high river stages within 12 to 24 hours before the event because of updates on weather, precipitation amounts, and reservoir and river levels. Two days before the full force of the 1997 subtropical series of storms was unleashed, forecasters predicted that 40 inches of rain would fall in the upper Feather River watershed, which was within 1 inch of the actual downpour.

On large, slower-moving rivers such as the Sacramento and San Joaquin, forecasters can predict high river stages more than 48 hours in advance because releases from upstream dams can take days to flow down the river. In contrast, on smaller, faster-moving rivers, such as the Eel and Smith on the north coast of California, and most Southern California waterways, officials can produce accurate flood warnings no more than 12 hours ahead of time.

Weather patterns arising from El Niño and La Niña weather conditions worry climatologists and flood managers. El Niño refers to unusually warm currents along the coasts of Peru and Ecuador, which heat other parts of the ocean and atmosphere. This weather phenomenon can increase tropical water temperatures in the eastern Pacific by 3° to 5° Fahrenheit, and in some places the waters can peak at more than 10°F higher than normal (up from temperatures in the low 70s F to the high 80s). In addition there can be heavier and more frequent storms, particularly in Southern California. The El Niño event in 1982-1983 brought more than 26 inches of rain. A record 37.7 million acre-feet flowed through the Sacramento River system. The winter of 2004-2005 saw the return of a weaker El Niño, which contributed to record-breaking precipitation numbers in many parts of Southern California.

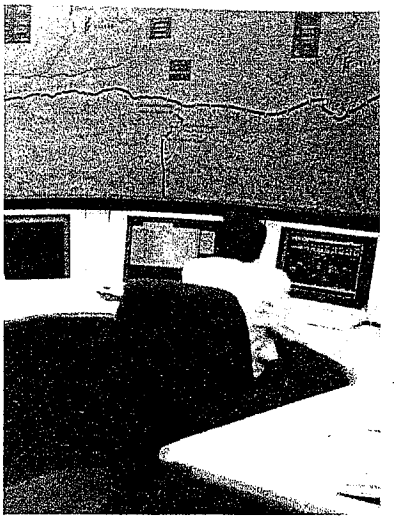
La Niña, the inverse of El Niño, has a correlation to intense wet, warm storms and is caused by the interaction of cold surface ocean water near the equator and air. The floods of 1955 and 1964 happened in La Niña years.

Technological advances such as improved satellite and radar imagery allow agencies to consider a new flood management that moves beyond the conventional protocol of releasing water whenever capacity exceeds allowable storage to a more flexible system that anticipates storm surges and plans accordingly. This may mean flood releases in advance of an arriving weather front or spring deluges kept as storage for beneficial use. Revised operations are being looked at, among other places, New Bullards Bar on the Yuba River and New Don Pedro Reservoir on the Tuolumne River.

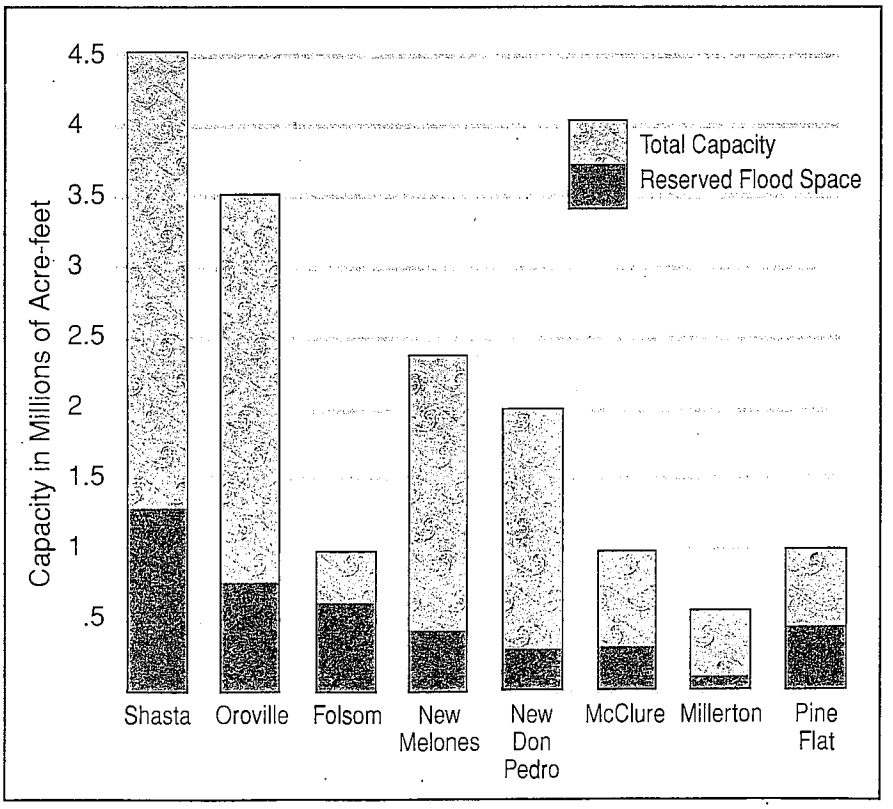
In addition, earlier melt patterns because of climate change may require new forecast bulletins, such as a March to May runoff forecast, to complement existing April-July water supply forecasts.

Runoff figures for the Sacramento River show a decrease in the fraction of yearly runoff from April to July over the past 100 years, DWR has noted, indicating a greater percentage of runoff is occurring earlier in the year. That's when flood management needs supersede water storage in reservoirs with flood management and water supply purposes. However the trend was not identified as statistically significant.

The uncertainty lies in the magnitude of these changes and any changes associated with the frequency and



At the State/Federal Flood Control Operations Center in Sacramento, hydrologists, weather forecasters and others work together to coordinate flood fights and reservoir releases.



magnitude of future floods and droughts. Earlier melt times, greater variability and greater potential for direct storm runoff may challenge the current system of flood protection and water supply in the state.

There also is the potential threat for major Sacramento-San Joaquin Delta levee failures caused by climate change-induced sea level rise when storms hit. "Global warming," the governor's office states, "means more floods and droughts." Current weather trends and climate models suggest the state will lose at least 25 percent of its snowpack by 2050. "More rapid runoff will require adequate storage to prevent flooding."

Local Flood Warnings

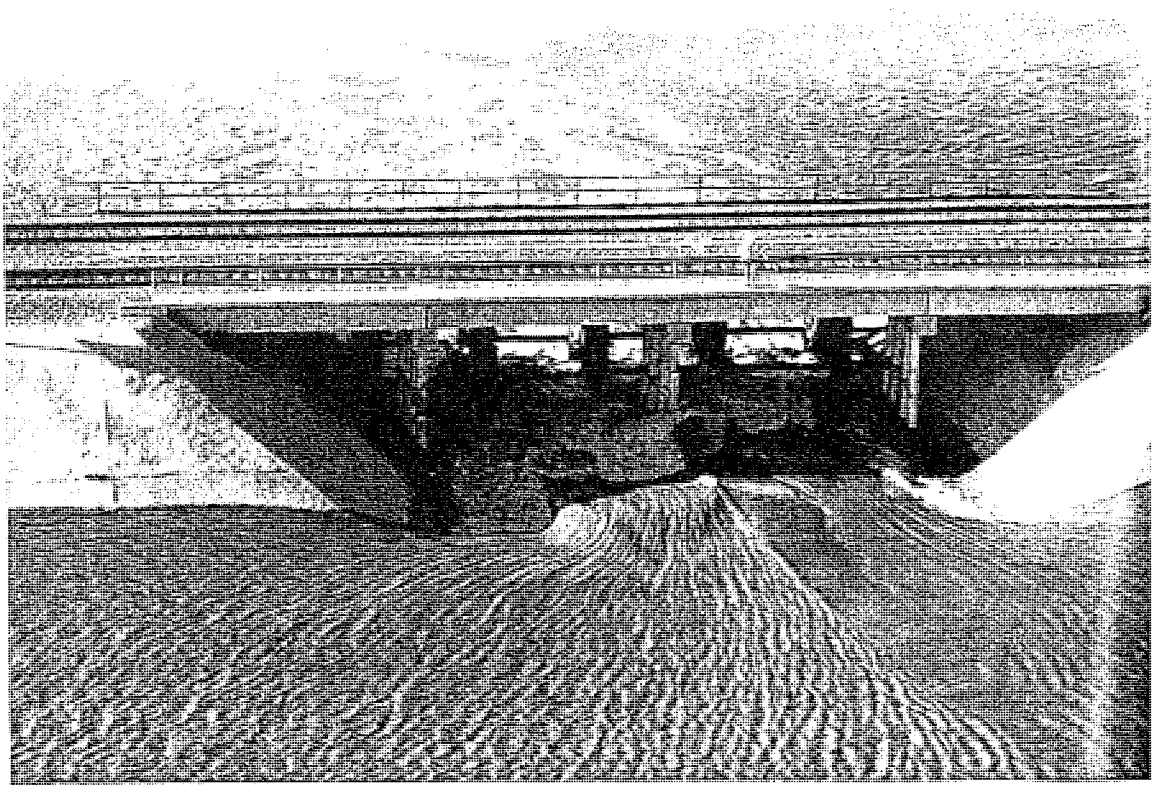
In regions more susceptible to flash flooding, local entities often take over flood warning responsibilities. They work closely with the River Forecast Center or the nearby NWS office. Many areas in Southern California and along the central and north coasts developed cooperative programs called ALERT (Automated Local Evaluation in Real Time). Under the ALERT programs, precipitation is measured by gauges in the watershed linked to computer models adapted to local situations, which determine expected runoff.

With adequate calibration and distribution of rain gauges within the watershed, an ALERT system provides timely information to help determine whether to evacuate. It also pinpoints areas of greatest concern, allowing more effective use of emergency personnel, the probable extent of the flooding and a response plan.

The system has been credited with saving lives and property during floods in California communities. One of the most significant events was a storm that struck the city of Petaluma in 1983. City officials were told at 4 a.m. that flooding was imminent according to the ALERT system. Officials contacted emergency crews and by 5:15 a.m. an emergency center was set up and evacuation vehicles were dispatched. Less than 40 minutes later, police and firefighters were going door-to-door to 321 residences in low-lying areas to deliver evacuation warnings. In less than an hour, flood waters raced through the residential streets and poured into the houses in the evacuated areas. No loss of life was reported, and the ALERT system was given much of the credit.

The Petaluma system consists of only one simple watershed. In Southern California, for example, Los Angeles County's ALERT system consists of 33 watersheds, which contain 15 dams and extensive downstream channel systems. Forecasting with this system is extremely complex, requiring extensive monitoring of the flows going into the dams and heading downstream.

Levees protect not only people, homes and farms, but vital infrastructure such as roads, railroads and power lines.



Ongoing and Proposed Projects

About 100 flood management projects are underway in California, most involving smaller streams. The $1.8 billion Santa Ana River Mainstem Flood Control Project, which aims to protect people and property in San Bernardino, Riverside and Orange counties, is the largest project.

The Seven Oaks Dam on the upper Santa Ana River was completed in 1999 and significantly increased the capacity of the Prado Dam spillway and outlet. Downstream of Prado Dam, more than 20 miles of the 30-mile river were channelized and levees were either strengthened or constructed. Mitigation for environmental damage by the project includes a 1,700 acre- preservation area in the Santa Ana Canyon and the construction of salt marsh habitat for endangered species.

In 1992, the Corps studied the Los Angeles County Drainage Area system and determined that the system lacked adequate capacity to prevent catastrophic flooding in the lower reaches of the Rio Hondo Channel and the Los Angeles River. Many reaches of the system provided only a 25 to 40-year level of protection largely due to increased runoff from developed areas and an improved storm drain system.

A resulting project finished in 2002 modified structures and improved levees on the waterways to restore a 133-year storm flood protection to 500,000 residents, 177,000 structures and 14 communities in Los Angeles County. Flood insurance requirements were met, eliminating $32 million annual premiums for mandatory flood insurance.

As much of the flood management system in Southern California has been effectively constructed to protect the urban landscape from flooding over the past 80 years, the challenge for the next generation of flood managers is to maintain an aging infrastructure while implementing the vision of watershed management.

Alluvial fans also present unique challenges to flood managers. Formed at the base of mountain ranges, alluvial fans siphon fast flowing water onto a flatter plain. Flood risk is high, especially in areas that have been scorched by wildfires. Rainfall can create flash floods, and the extent of damage can be more extensive than that in upstream canyons because high-velocity flows shoot down tons of sediment and rock.

Alluvial fans are found throughout California, yet mostly in Southern California in San Bernardino, Riverside, Los Angeles, Ventura, Santa Barbara, San Luis Obispo, Kern, Imperial, Orange, and San Diego counties.

One concern is growth forecasts that estimate communities located at the base of flood-prone alluvial fans will accommodate up to 60 percent of the new development occurring in Southern California in the 21st century.

In 2004, following a post-fire debris flow that claimed 16 lives in San Bernardino County, the Governor directed DWR to seek federal funding for the Alluvial Fan Task Force. In 2007, DWR announced a partnership with the California State University to develop an ordinance and local planning tools for future land use decisions regarding alluvial fans. Funding was made available through a pre-disaster mitigation grant from FEMA.

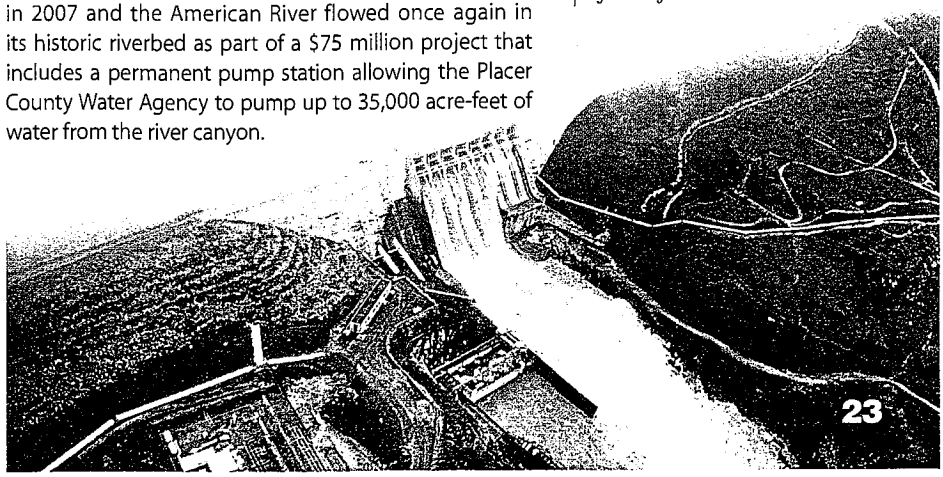
In Northern California, the focus remains on strengthening levees and bolstering dams. Congress authorized a $24.7 million comprehensive flood protection package for the Sacramento region in 2004 to improve levees along the American River, and also add flood gates to Folsom Dam and increase its height by seven feet to improve storage capacity.

In 2007 Reclamation awarded the first in a series of contracts for work on the new auxiliary spillway at Folsom Dam. The project represented an unprecedented partnership with the Corps, DWR and SAFCA. As a result, the dam will be able to face a 200-year flood without exceeding the downstream levee capacity and also be able to withstand the probable maximum flood beyond a 500-year flood.

The proposed Auburn Dam, located on the north fork of the American River above Folsom Dam, was first authorized for construction in 1965 and featured a 690-foot-high dam and a 68-mile canal to San Joaquin County. Construction of the dam stopped in 1975 after an earthquake struck the Oroville area, 41 miles north of Auburn, and new seismic considerations were built into the design. Changes in federal cost-sharing rules, as well as a growing disagreement among project proponents, environmental groups, national taxpayer organizations and wildlife agencies over long-term impacts raised additional issues and delayed the project. In late 2008 the State Water Board unanimously voted to revoke the water rights under California's "use-it-or-lose-it" water laws that stated Reclamation had to put its rights to American River water to beneficial use.

While work on the dam has stopped, restoration work on the American River has not. A half-mile segment of the river outside Auburn that was diverted for 30 years through a tunnel built for the Auburn Dam project was sealed off in 2007 and the American River flowed once again in its historic riverbed as part of a $75 million project that includes a permanent pump station allowing the Placer County Water Agency to pump up to 35,000 acre-feet of water from the river canyon.

Folsom Dam releasing flood flows.



Summary

The uncertainty of climate change and the lessons of Hurricane Katrina are new issues for a California already facing an increasing population, shrinking budgets and an aging infrastructure. Katrina has helped alert California to improve its flood protection measures.

Flood management still faces significant obstacles. Many floodplains already are developed and providing rivers with more room to roam is controversial, expensive and nearly impossible. Virtually all of the natural floodplains along the Los Angeles River are urbanized. Much of the city of Sacramento lies in the historic floodplain. Other areas throughout the state are experiencing rapid development.

Dams are credited with helping to provide flood reduction or management but also seen as allowing new development in areas protected by levees that may be inadequate.

Floods affect every Californian because public funds pay for damages and flood management projects.

Floodplain development continues to be a controversial matter. While local land use planners and regulators must weigh many factors when deciding what areas should be developed, many are concerned that unchecked building in floodplains is shortsighted given the risk of flooding and increased total infrastructure costs needed for protection. Others say, however, that development can provide the economic base to support flood management projects.

Legislation signed in 2007 by the governor is intended to address the problems of development in the flood-prone Central Valley by requiring cities and counties to increase consideration of flood risks when making land use decisions, as well as create a new standard in flood protection for urban development in the region.

Integration of regional flood management plans is also an important part of the broader picture of water resource management in California, given the state's dependence on a relatively short rainy season to meet its annual need.

As California continues to confront the century-old problem of floods and how to manage them, the new issue of climate change has emerged to further complicate the quandary. As one water expert pointed out, "We have to learn to work with the historic forces of the river, not against them."